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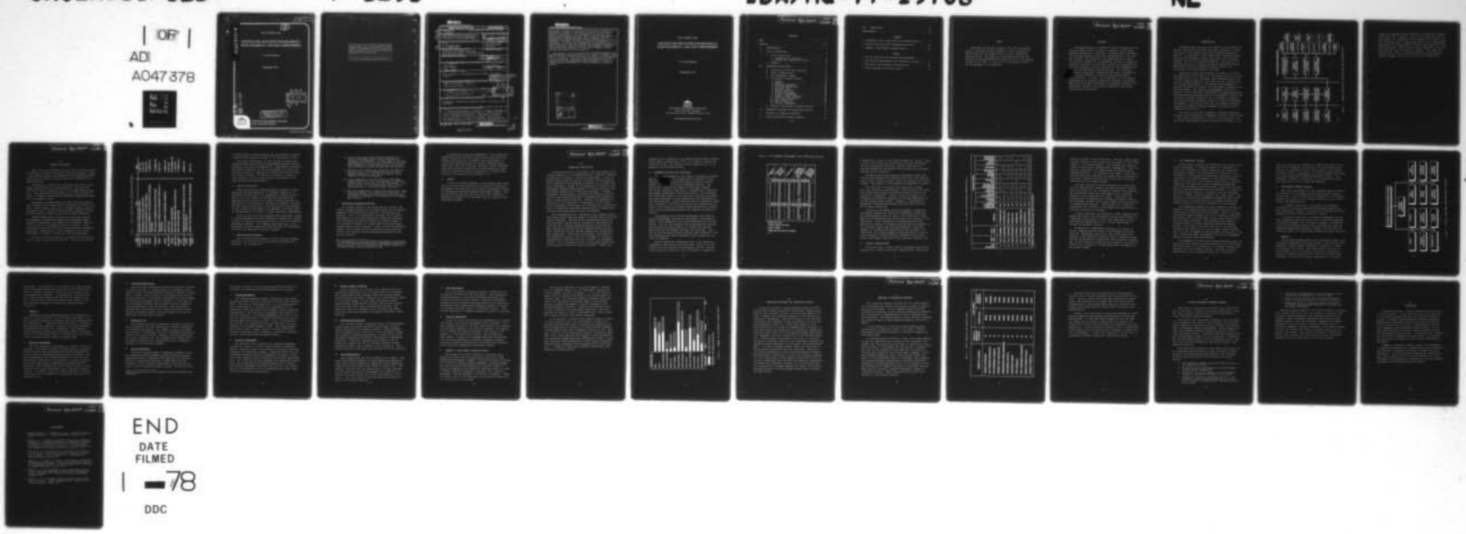

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CONTRACTOR INITIATIVES FOR RELIABILITY, MAINTAINABILITY, AND COST IMPROVEMENT

C. David Weimer

September 1977

INSTITUTE FOR DEFENSE ANALYSES
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) P-1291	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) CONTRACTOR INITIATIVES FOR RELIABILITY, MAINTAINABILITY, AND COST IMPROVEMENT.		5. TYPE OF REPORT & PERIOD COVERED (9) Final rept.,
		6. PERFORMING ORG. REPORT NUMBER P-1291
7. AUTHOR(s) (10) C. David Weimer		8. CONTRACT OR GRANT NUMBER(s) IDA Independent Research
9. PERFORMING ORGANIZATION NAME AND ADDRESS Institute for Defense Analyses 400 Army-Navy Drive, Cost Analysis Group Arlington, VA 22202		10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE (11) September 1977
		13. NUMBER OF PAGES 41
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) (12) 41p.		15. SECURITY CLASS (of this report) Unclassified
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

This document is unclassified and suitable for public release.

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(18) IDA/HQ, SBIE

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18. SUPPLEMENTARY NOTES

(19) 77-19798, AD-E500 010

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Management, Acquisition, Design-to-Cost, Life-Cycle Cost, Warranty

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper presents a synthesis of major findings and conclusions derived from four years of research in electronics subsystem acquisition. Department of Defense policy statements for achieving improved reliability, maintainability, and cost are reviewed. The application and implementation of these policies are examined and the → over

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management response of system and subsystem contractors is described in areas of operating policies and procedures, project organization, cost management and control, and development program planning. The contractor experiences during their engineering development programs are subsequently evaluated in terms of operating problems or policy barriers. In total, the experiences of 43 contractors responding in 25 separate programs are examined and analyzed. Based upon their past experiences and management behavior, the appropriate response to successfully embrace future policy initiatives is postulated.

This paper is to be presented at the 1978 Reliability and Maintainability Symposium held in Los Angeles, January 17-19, 1978. It also is to be published as part of the proceedings of the symposium. This paper has been prepared with the permission of the symposium program committee in order to permit greater distribution of the information contained herein.

IDA PAPER P-1291

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September 1977

IDA

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IDA Independent Research Program

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CONTENTS

FIGURES

TABLES

NOTE

This paper was written as part of the IDA Cost Analysis Group's continuing research program on "Cost Concepts and Methodology" and was funded as part of IDA's independent research effort. The paper is to be presented at the 1978 Reliability and Maintainability Symposium held in Los Angeles, January 17-19, 1978. It also is to be published as part of the proceedings of the symposium.

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ABSTRACT

This paper presents a synthesis of major findings and conclusions derived from four years of research in electronics subsystem acquisition. Department of Defense policy statements for achieving improved reliability, maintainability, and cost are reviewed. The application and implementation of these policies are examined and the management response of system and subsystem contractors is described in areas of operating policies and procedures, project organization, cost management and control, and development program planning. The contractor experiences during their engineering development programs are subsequently evaluated in terms of operating problems or policy barriers. In total, the experiences of 43 contractors responding in 25 separate programs are examined and analyzed. Based upon their past experiences and management behavior, the appropriate response to successfully embrace future policy initiatives is postulated.

I
INTRODUCTION

During the past six years, the Office of the Secretary of Defense (OSD) and the Services have been attempting to change the output of the weapons system and subsystem acquisition process. In particular, these offices have initiated acquisition policies designed to reduce cost growth and to improve equipment reliability and maintainability. The focus of the policies has been the critical design and development phase, where basic decisions influencing future product cost, reliability, and maintainability are made.

Electronics system and subsystem contractors can pursue the objectives of the policies in two primary ways; (1) through the application of new technology which promises greater simplicity, higher reliability, and lower cost per function; and (2) through improvements in the planning and management of program activities for reduced cost and higher reliability during development. The planning and management function is believed to be as critical a determinant of program outcome as new technology utilization--there is considerable evidence that the benefits gained through the use of advanced electronics technology have been partially offset by increased performance requirements. The results often have been greater equipment complexity, leading to reduced equipment reliability and increased life-cycle cost.

The topic of contractor response to defense acquisition policies can be displayed in diagramatic form as shown in Figure 1. The figure illustrates the flow of policy directives and subsequent implementing instruction from the government to the

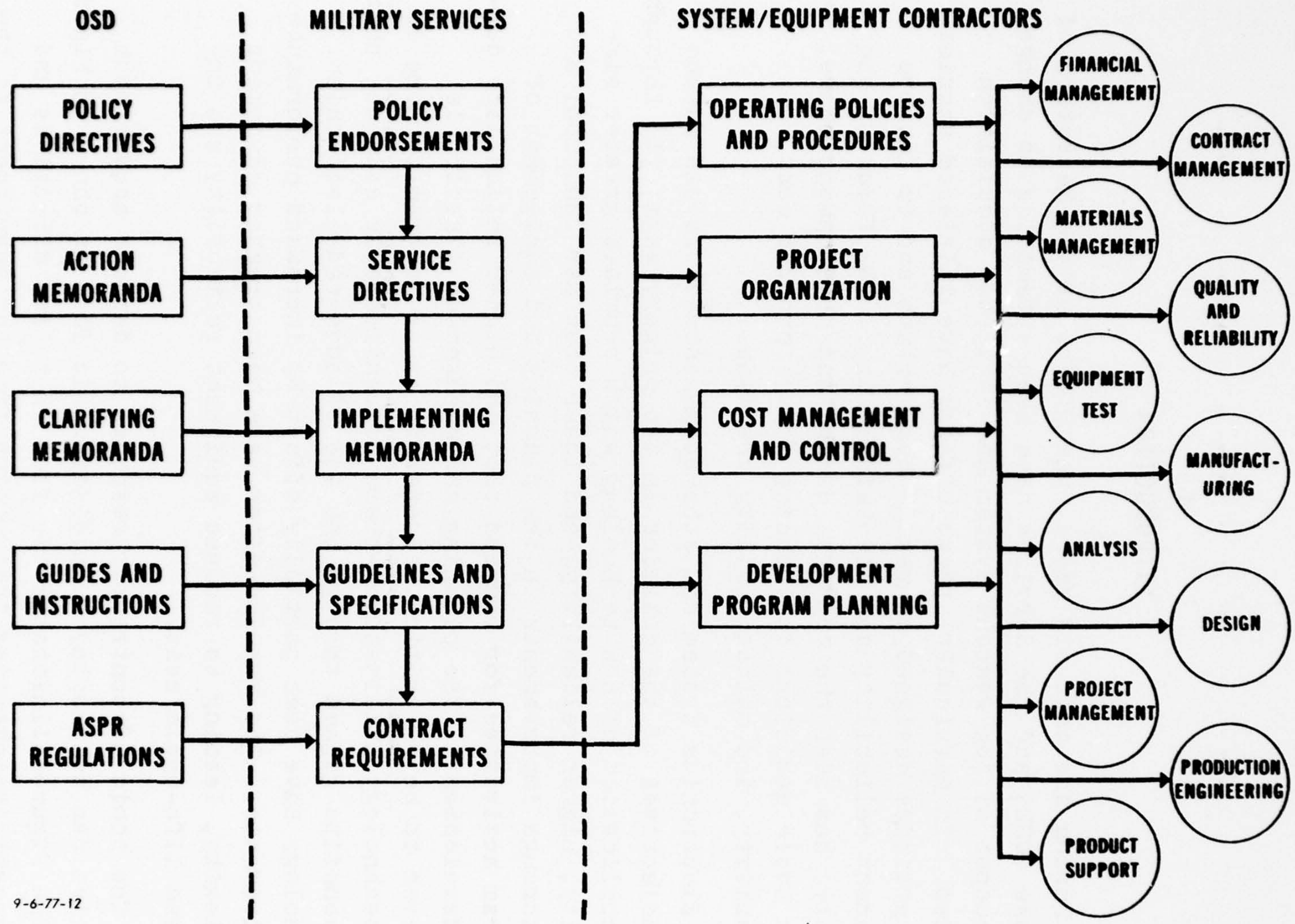

Figure 1. ACQUISITION POLICY APPLICATION AND IMPLEMENTATION

contractor organization and eventually to functional organizations within the contractor. Even in this simplistic view of the process, the contractors do not operate in a vacuum. Outside influences exist, ranging from other forms of governmental intervention to the political, economic, and competitive business environment. These external forces frequently enter into and alter the form of contractor response. This paper will examine some of the key contractor functions illustrated to identify changes that result from new policy application.

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II

POLICY INITIATIVES

Major DoD policy statements take the form of DoD Directives or Memoranda to Service Secretaries from OSD principals. Table 1 lists several recent policy directives and implementing memoranda that are directly concerned with cost, reliability, or maintainability.

The emphasis of these policy directives has been on cost rather than reliability or maintainability. The first DoD Directive, 5000.1, established cost as a primary design parameter. This launched the DoD Design-to-Cost (DTC) acquisition policy. Subsequent directives and memoranda expanded and amplified the original concept.

Reliability and Maintainability (R&M) objectives usually were contained in the directives as surrogates for support cost goals. Where present, they were to be given emphasis equal to acquisition costs. Specific policy guidance tailored for R&M has only recently surfaced in the form of draft directives.

The major R&M policy initiatives to date have been the establishment of Reliability Improvement Warranties (RIWs), reliability guarantees, and Support Cost Guarantees (SCGs) as contract options to equipment production contracts. These requirements emphasize field R&M through equipment performance guarantees. Application of these techniques to new system procurements increased following the 1973 RIW memorandum.

Two new draft policy directives, presently being reviewed prior to issue, deal directly with R&M. They call for methods

Table 1. POLICY DIRECTIVES AND IMPLEMENTING MEMORANDA

FORM	TITLE	DATE
DoDD 5000.1	ACQUISITION OF MAJOR WEAPON SYSTEMS	13 JULY 1971
(MEMO)	DEVELOPMENT OF PRICE-LIMITED PROTOTYPES	10 JULY 1972
(MEMO)	DESIGN-TO-COST OBJECTIVES ON DSARC PROGRAMS	18 JUNE 1973
(MEMO)	TRIAL USE OF WARRANTIES IN THE ACQUISITION OF ELECTRONIC SUBSYSTEMS	17 AUGUST 1973
GUIDEBOOK	JOINT LOGISTICS COMMANDERS GUIDE ON DESIGN-TO-COST	3 OCTOBER 1973
(MEMO)	APPLICATION OF DESIGN-TO-COST MANAGEMENT PRINCIPLES TO SUBSYSTEMS	24 MAY 1974
(MEMO)	TRIAL USE OF RELIABILITY IMPROVEMENT WARRANTIES	14 AUGUST 1974
DoDD 5000.28	DESIGN-TO-COST	23 MAY 1975
(MEMO)	DESIGN-TO-COST IMPLEMENTATION	30 SEPTEMBER 1975
GUIDE (REV)	JOINT LOGISTIC COMMANDERS GUIDE ON DESIGN-TO-COST	11 JUNE 1976
DoDD 5000.1 (REV)	MAJOR SYSTEM ACQUISITIONS	18 JANUARY 1977
DoDD 5000.xx (DRAFT)	OPERATING AND SUPPORT COST MANAGEMENT IN THE SYSTEMS ACQUISITION PROCESS	JANUARY 1977
DoDD 5000.xx (DRAFT)	RELIABILITY AND MAINTAINABILITY OF SYSTEMS AND EQUIPMENT	APRIL 1977

to predict R&M of proposed systems and consideration of R&M as a major concern during all phases of the acquisition process.

Note that--particularly for DTC policies--several years elapsed between initial policy establishment and more specific guidelines for Service implementation. Refinements incorporating lessons learned on the initial experiments or trials subsequently resulted in updated and revised policy directives as the concepts matured. To understand contractor response to these policies, we will briefly examine the manner in which these policies have been applied.

A. POLICY APPLICATION

While the DoD policy directives may be explicit in their objectives and the approach to be followed, changes in the acquisition process and in the management of product development do not occur unless the policies are translated into implementing instructions and contract clauses reflecting the application of the policies to the specific program. No matter how much publicity was given to the new policies, the response of many contractors was found to be dependent upon their specific interpretation of current or future contractual commitments.

Since the initial policy statements were published, studies at IDA and elsewhere have been conducted to measure the progress of these initiatives as they were applied to the first candidate development programs. The findings, described below, are of particular interest because they form the basis for explanatory rationale for subsequent contractor behavior.

1. Design-to-Cost Policies

The contractual requirements for eight original programs designated by the Services as price-limited prototypes were analyzed. Key findings were:

(1) Seven of the eight price-limited prototypes had entered development *before* being designated as a design-to-cost candidate. At least four of the eight experiments were well into their engineering development programs at a stage where most of the critical design decisions already had been made and approved.

(2) Because of the timing, the contractual DTC application for most of the programs resulted in either amended provisions to the initial contract or incomplete contract requirements.

(3) A key ingredient of the DTC policy is development program flexibility (cost and schedule) in order to perform design iterations for goal achievement. Only thirty percent of the programs were able to obtain additional time or funds for design iterations.

(4) The most inconsistent contract requirement was in the area of equipment cost estimating and reporting. The Government in many cases had little visibility into the status or progress of the production cost management efforts.

2. Reliability Guarantee Policies

In a manner similar to the design-to-cost policies, the initial programs containing future requirements for reliability guarantees or warranties were analyzed. The findings were parallel. Most of the development contracts did not specify requirements for the future guarantees; terms and conditions were negotiated and finalized during the terminal stages of the development program, at a stage where little development program impact could be realized. Unlike the DTC requirements, however, the finalized contract requirements were generally complete and followed uniform guidelines established by OSD and the Services.[1]

[1]The author believes this can be attributed in large measure to the advisory role the ARINC Research Corporation played in assisting the Services design warranty provisions. Thus, the Army and Air Force contract clauses are constructed uniformly and read very much the same.

An additional contractual ingredient of the reliability guarantees was the potential financial risk associated with warranty provisions and consignment spare requirements if future field reliability did not achieve predicted values. Contractors found that they were required to price warranties based upon specified reliability and maintainability levels with only limited development program data to predict their ultimate field reliability and warranty cost.

B. SUMMARY

In the two policies examined, it was observed that translation of broad policy directives into specific contractual requirements took time and was not easily accomplished during an on-going and previously planned development program. This was particularly critical when the policy was intended to influence the design of the equipment and the conduct of the development program.

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III

CONTRACTOR INITIATIVES

A primary objective of this paper, and a key output of our previous research, is the identification of contractor response or behavior as a result of the policy directives. It will be several years before the success or failure of these policies can be determined from equipment production cost or field operating performance; changes in the management or conduct of the development program, giving emphasis to policy objectives, may be reliable indicators of future policy success. Of equal importance, problem areas or barriers that prevent policy objectives from being pursued may be discovered and resolved in time to obtain positive benefits. Finally, the aggregate experiences of the contractors in responding to these recent policy initiatives should help other contractors or subcontractors in formulating development program plans and negotiating contracts containing similar policy requirements.

Our investigations into contractor policy response identified several areas where the impact of the DoD policy directives could be observed. Contractors who successfully adopted the new acquisition policies did so through the formalization of their own new or revised operating policies and procedures. This effectively endorsed the new acquisition mode and provided credibility for the internal changes that subsequently were implemented. Contractual requirements, reflecting the new acquisition policies, also led to changes in contractor organizational structures and their internal cost management systems. As the discipline evolved for achieving greater cost and reliability visibility during development, changes were

observed in the planning of the engineering development program. These changes required more effort to be spent in several key functional areas. The details of these responses will be examined in the following sections.

A. CORPORATE POLICIES AND PROCEDURES

If pe[illegible]ment changes in the conduct of design and development pro[illegible]o be accomplished, we expected to find either ne[illegible]ed corporate operating policies and procedures that [illegible]ted the new Government policies. DTC represented a significant change in development program priorities; therefore, some means of legitimizing or authorizing program planning for DTC was anticipated. Our investigation found that sixteen of the twenty-two contractors surveyed had either developed or were preparing new DTC operating policies and procedures. Contractors who were not responsive stated that corporate or divisional directives were inappropriate because of the variety of programs being accomplished or because other existing procedures provided the guidance necessary to respond.

Investigations into the DTC requirements that affected policy establishment identified requirements, illustrated in Table 2, which apparently led to the formalization of the DTC process. All but one contractor who established DTC policies and procedures had requirements for frequent and periodic production-cost estimating, tracking, and reporting. Only half of the contractors without policies were subjected to any cost-reporting, and these requirements were minimal--two reports per program.

Another significant difference found in the contractor requirements was provision for award fees. Most of the contractors with DTC policies and procedures were also working toward award fees based upon their willingness to negotiate

Table 2. DTC CONTRACT REQUIREMENTS AND CONTRACTOR POLICIES

CONTRACTOR CODE	PRODUCTION COST GOAL SPECIFIED	COMPETITION	PERIODIC PRODUCTION COST REPORTING AND TRACKING	AWARD FEE BASED UPON PRODUCTION UNIT COST
CONTRACTORS WITH DTC POLICIES AND PROCEDURES				
B	YES	YES	YES [a]	NO
H	YES	YES	YES [b]	YES
M	YES	YES	YES [a]	YES
Q	NO	NO	YES [a]	NO
R	YES	YES	YES [b]	YES
S	YES	YES	NO	YES
T	YES	NO	--- [c]	YES
V	YES	YES	YES [a]	YES
P	NO	YES	YES [b]	NO
CONTRACTORS WITHOUT DTC POLICIES AND PROCEDURES				
D	YES	NO	YES [d]	YES
E	NO	YES	NO	NO
G	YES	YES	NO	NO
J	YES	YES	NO	NO
K	YES	YES	YES [d]	NO
O	YES	YES	YES [d]	NO

[a] Monthly cost reports.
[b] Program milestone cost reports.
[c] Data not available.
[d] Design reviews only (two per ED program).

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a production contract at the product design cost (price). Thus, a causal relationship was found between contract requirements for cost tracking and reporting, contract incentives for achieving production cost goals, and the policy and procedural response of the contractor.

The DTC policies and procedures furnished by eight contractors were examined for characteristics that would indicate scope, level of detail, origin, source of authority, and topics covered. The results of this analysis are presented in Table 3.

The final area for analysis was functional coverage. Functions relating to organizational relationships, cost tracking, product engineering, and production were covered by the majority of contractors. However, uniform coverage of cost estimating or validation testing--two critical ingredients in the DTC concept--were lacking. Emphasis on subcontractor management or material-purchasing functions were covered by six of eight contractors.

Policies or procedures governing changes to design and development programs for improved or guaranteed reliability and maintainability were not found in our contractor surveys. Based on our experience with DTC policies, this finding was not surprising. In the reliability and maintainability area, specific new reports or program activities were not required by the Government during engineering development. Therefore, changes for increased R&M responsibility did not have to be formalized; each program manager could take whatever steps he felt necessary to acquire R&M data, demonstrate his future product performance, and quantify his potential warranty risk.

B. PROJECT ORGANIZATIONS

The second area of policy impact investigated was project organization. Several significant organizational changes were

Table 3. DTC POLICY AND PROCEDURE CHARACTERISTICS

CONTRACTOR CODE	ISSUE DATE	APPLI-CATION	AUTHORITY	FUNCTIONS COVERED										
				GOVERNMENT REQUIREMENTS REFERENCE	GENERAL GUIDELINES	RESPONSIBILITIES OUTLINED	PROCEDURES SPECIFIED	ORGANIZATIONAL RELATIONSHIPS	COST ESTIMATING	COST TRACKING	PRODUCT ENGINEERING	PRODUCTION	VALIDATION TESTING	SUBCONTRACT MANAGEMENT
B	APR 74	PROGRAM	VP/PROGRAM MGR.	YES	X	-	X	X	X	X	-	-	-	X
H	AUG 72	DIVISIONAL	VP/GENERAL MGR.	NO	X	X	X	X	-	-	X	X	-	-
M	JUL 74	DIVISIONAL	DIVISION PRES.	YES	X	-	-	X	-	X	X	X	-	X
Q	MAR 69	DIVISIONAL	DIVISION PRES.	NO	X	X	X	X	-	X	X	X	-	X
R	APR 74	PROGRAM	PROGRAM MGR.	YES	X	X	X	X	X	X	X	-	X	-
S	OCT 73	PROGRAM	VP/PROGRAM MGR.	NO	X	X	X	X	-	X	X	X	-	-
T*	OCT 73	DIVISIONAL	ENGINEERING VP	NO	X	X	-	X	-	X	X	-	-	X
V	JUN 74	PROGRAM	PROGRAM MANAGER	YES	X	X	X	X	X	X	X	X	X	X

* Contractor T issued both division and program policies and procedures.

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found as a result of the new policies. The most common organizational response to DTC policies was the addition of DTC staff support to the program manager. This response was especially common in pure project organizational arrangements. Other contractors created DTC line organizations or specialized DTC engineering staffs. All contractors who added to their engineering staffs were organized in a matrix form, each member of the project organization reporting to both their functional supervisor and the program manager.

The most influential factors believed to be responsible for the organizational changes were again Government requirements for production cost estimating, tracking, and reporting. Ten contractors stated this requirement to be a principal reason for their organizational change. Contractors also believed that the emphasis and importance attached to DTC by the Government program offices were primary motivating factors in organizational response. Other reasons for change were requirements for life-cycle cost analyses and continuing producibility analyses and planning.

Several contractors who reported no formal organizational change responded to DTC requirements through establishment (on a periodic or need basis) of *ad hoc* DTC committees, or they used existing organizations (e.g., systems engineering) to provide the necessary response.

In addition to organization structure, the content of project organizations was found to be influenced by the new policies. Significant additions to the project staff were observed in the functional specialty areas of production engineering, maintainability engineering, and reliability engineering. These functional disciplines were needed to help predict product cost, reliability, and maintainability throughout the development program.

C. COST MANAGEMENT CHANGES

As the policy concepts were translated into specific contract requirements, it became necessary for contractors to devote more attention to future production cost during the development program. DTC requirements for production cost estimates at the beginning of engineering development and the requirements for periodic updates of the initial estimates meant that contractors would develop capabilities to estimate production cost based upon early conceptual descriptions, track these estimates at detailed levels, and report the estimates to internal management and the Government. In order for the design-to-cost goals to be achieved, the cost estimates had to be visible to design engineers on a timely basis. This required a time-sensitive management information system that would provide cost estimators with new design concepts and design engineers with the cost estimates of their designs.

Cost management changes were also required as reliability warranties and guarantees were introduced as options to be priced prior to production contract award. Early in the engineering development program, the cost of contractor repair and maintenance had to be considered so that these factors could also influence the design. Cost estimates were needed to influence repair or replace decisions during the warranty period. And in order to estimate the cost of the warranty, estimates were needed for the cost of repair labor and materials, the cost of diagnostic and acceptance testing, and in the case of guaranteed MTBF requirements, the cost of consignment spares to maintain field availability.

The management of future costs during the design phase required that the contractor become proficient in at least three functional areas; cost estimating, cost estimate tracking and reporting, and cost estimate control. For many contractor organizations, these requirements were new. Contractors

were just beginning to implement the latest Government requirements for the management and control of on-going development programs in accordance with DoD cost/schedule control-systems criteria (C/SCSC). Requirements for future equipment and operations cost estimating represented additional efforts. New management information systems had to be developed and existing capabilities in cost estimating augmented.

D. DEVELOPMENT PROGRAM PLANNING

The final, and perhaps the most important area of contractor response, is development program planning and execution. In this case, we are concerned with changes made to development programs as a result of the increased emphasis on cost, reliability, and maintainability.

As a frame of reference, a functional work breakdown structure for a typical engineering development program has been constructed. Figure 2 illustrates the thirteen functional elements that were analyzed during the research.

It should be noted that the financial management and contract management functions usually are not directly chargeable to specific programs; they are indirect charges. Nevertheless, since previous research showed these functions were impacted, exhibiting significant responsive changes, they have been included as a part of the development program functional structure.

1. Design

The equipment design efforts were increased for many of the contractors responding to the new policies. DTC policies often resulted in several design iterations to maintain or achieve the production cost goals. More design effort also was required under policies of potential reliability warranties or guarantees because contractors were required to design their equipment for either field organic maintenance or contractor

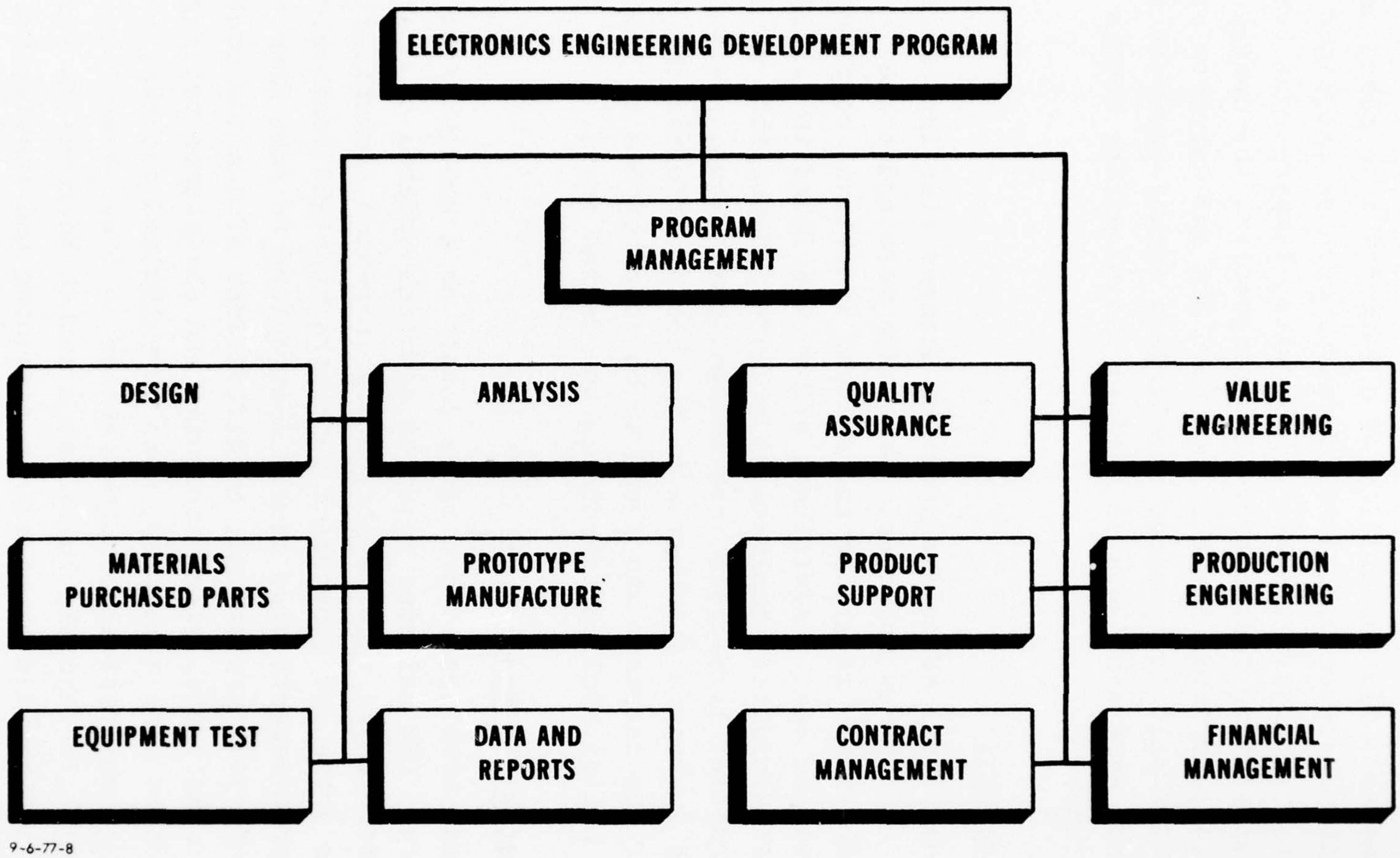

Figure 2. TYPICAL FUNCTIONAL WORK BREAKDOWN STRUCTURE

maintenance. The possibility of a warranty also meant designs which incorporated additional features such as increased built-in-test, protective sensors or circuits, tamper-proof seals, and elapsed-time indicators. In perspective, the design function received large impacts from both DTC and warranty policies. DTC policies created the largest impact whenever time and funds were available to perform the necessary design iterations.

2. Analysis

Analytical efforts supporting designs also increased as a result of the new policies. New tasks were undertaken to explore alternate materials and analyze additional configurations for lowering cost. Additional effort was found in reliability and maintainability analyses to prepare for possible warranty or guaranteed life-cycle cost obligations. Thus, analytic efforts increased together with the design efforts; the magnitude of the increase was found to be proportional to the timing of the policy application during the design phase.

3. Materials Management

This area received a large impact as a result of the new policies. DTC policies required constant updates of projected production costs that significantly increased communications between prime and supporting subcontractors and vendors. Warranty requirements also caused contractors to take more care with material inspections, certifications of quality control, and in some cases, plant screening and acceptance testing. Contractors also attempted, with very limited success, to pass their new contractual requirements on to lower-level subcontractors. In general, there was a marked increase in supplier communications and in materials screening and testing prior to development use.

4. Prototype Manufacture

There had been considerable discussion within the industry concerning the need for larger numbers of development prototypes to support increased design verification and test requirements; however, little increase in prototyping effort was observed in practice. Two possible explanations are that funding for additional prototypes was not available, or that most of the development programs were structured without recognizing the need generated by the new policies. Most contractors believed they could benefit from a larger prototype or pilot production program; however, they were unable to obtain the additional time and money required.[1]

5. Equipment Test

This element received a significant increase in effort by those contractors who were preparing for potential warranties or reliability guarantees. In a number of cases, prototypes were subjected to additional tests not specifically required by contract test specifications. However, the DTC policies were not usually responsible for the increased test effort; most of the design iterations were accomplished prior to committing hardware to the major test programs.

6. Quality Assurance

Contractors reported small to moderate increases in quality assurance efforts primarily because potential warranty requirements made it imperative that materials and purchased parts be screened more carefully. Added effort was also expended to ensure complete documentation of system and component failures during development testing. DTC policies did

[1]This was especially true for those programs containing development phase competition.

not appear to impact the quality assurance efforts except for materials certification and receiving inspection functions.

7. Program Management

The program management element consistently rated highest among the elements that were affected by the new policy requirements. This was not surprising since it is the program manager's responsibility to interpret the requirements of the contractual effort and parcel work packages to other functional organizations. When new policy requirements were applied, it was more efficient to add program management staff than to disturb an on-going process or a company functional group that is handling many other projects as well. Thus, it was observed that the DTC cost tracking and reporting functions often were assigned to the program manager's staff. The program management staff is also a logical location for multi-functional analyses considering cost, performance, reliability, maintainability, and the development program schedule.

8. Financial Management

The response of the contractors in financial management occurred as a result of the DTC policies which, as discussed earlier, required product cost estimation at frequent intervals throughout the development program. Additional effort was also noted under warranty policies as management attempted to quantify future financial risks associated with warranty administration. All of the new policies demanded that contractors improve their cost estimating and forecasting capabilities. Because the financial management functional area was most often responsible for providing services or accomplishing this task, their efforts were increased substantially.

9. Product Support Planning

Support planning is a function that ordinarily does not contribute significantly until the second half of the development program when product designs reach the critical design review milestone and support concepts can be specifically linked to the product design. It was found that product support planning began sooner whenever warranty options were a possibility and more total effort therefore was required. DTC impact was found to be minimal except for those cases where life-cycle costs were critical to production contractor source selection.

10. Production Engineering

This function became a significant part of the development process under the DTC policies when producibility concerns affecting production cost became critical. Several program offices augmented their staff early in the development program with production engineering personnel in order that the first preliminary designs would benefit from production engineering visibility. Production engineering also played a role in designing equipment that could be tested, repaired or maintained efficiently under a warranty by the contractor. This function was one of the areas most affected by the new policies.

11. Value Engineering

Value engineering (VE) was an enigma in our studies. Some firms placed greater emphasis on value engineering during design, while others replaced the traditional value engineering function with *ad hoc* task forces formed to reduce costs. Our analyses indicated that the identification of value engineering with only the specific requirements and incentives of a contract VE clause restricted a broader application of this talent. Thus, the overall impact was relatively nominal for each of the policies examined.

12. Data and Reports

All of the policy initiatives resulted in additional requirements for contractor data and reports. DTC requirements surfaced primarily in the form of periodic production cost estimates and cost variance reports. Warranty requirements resulted in more detailed data being required from reliability demonstration test programs and planning documents to support the proposed contractor repair or maintenance concept. These policies resulted in a moderate increase in effort in this area.

13. Contract Management

As the new policy initiatives were translated into contract requirements, the contract management effort increased. Contract clauses calling for cost goal demonstrations and incentive fee provisions resulted in new contract analyses. The negotiation of complex and detailed warranty or GSC clauses to be applied to future production contracts also represented a large impact. In most of the programs examined, the formulation and mutual agreement on proposed contractual warranty provisions occupied several months of intensive and sustained effort during the engineering development program.

E. SUMMARY OF DEVELOPMENT PROGRAM RESPONSE

The acquisition policies examined in this paper had a significant impact upon the planning and execution of many engineering development programs. DTC policies greatly affected the functions of design, program management, materials management, and production engineering while policies leading to reliability guarantees and warranties impacted heavily in areas of design, materials management, equipment test, financial management, program management, and contract management. There is evidence that all the development functions were affected by the new policies to some degree.

The relative magnitude of the policy impacts, together with the aggregate impact upon the development program functional elements, are shown in Figure 3. It is seen from the figure that the policies contribute to the overall impact in different ways. DTC policies primarily concerned with acquisition cost compliment the warranty impact in the design, analyses, materials management, financial management, and program management functions. Warranty policies which focus on future operations and maintenance experiences (and cost) dominate the impact in areas of equipment test, quality assurance, product support, and contract management.

It is difficult to quantify the observed impact in terms of either effort or cost. For the warranty policies, our research indicated that those contractors who reported an impact estimated that it resulted in a twelve percent increase in development effort and a comparable increase in cost. However, only half of the contractors surveyed reported an impact. Most of the others reported that program or institutional barriers prevented taking additional development actions. It was also discovered that peculiarities of the program or barriers prevented most contractors from responding fully to DTC policies. A summary of these policy barriers identified by the research is presented below.

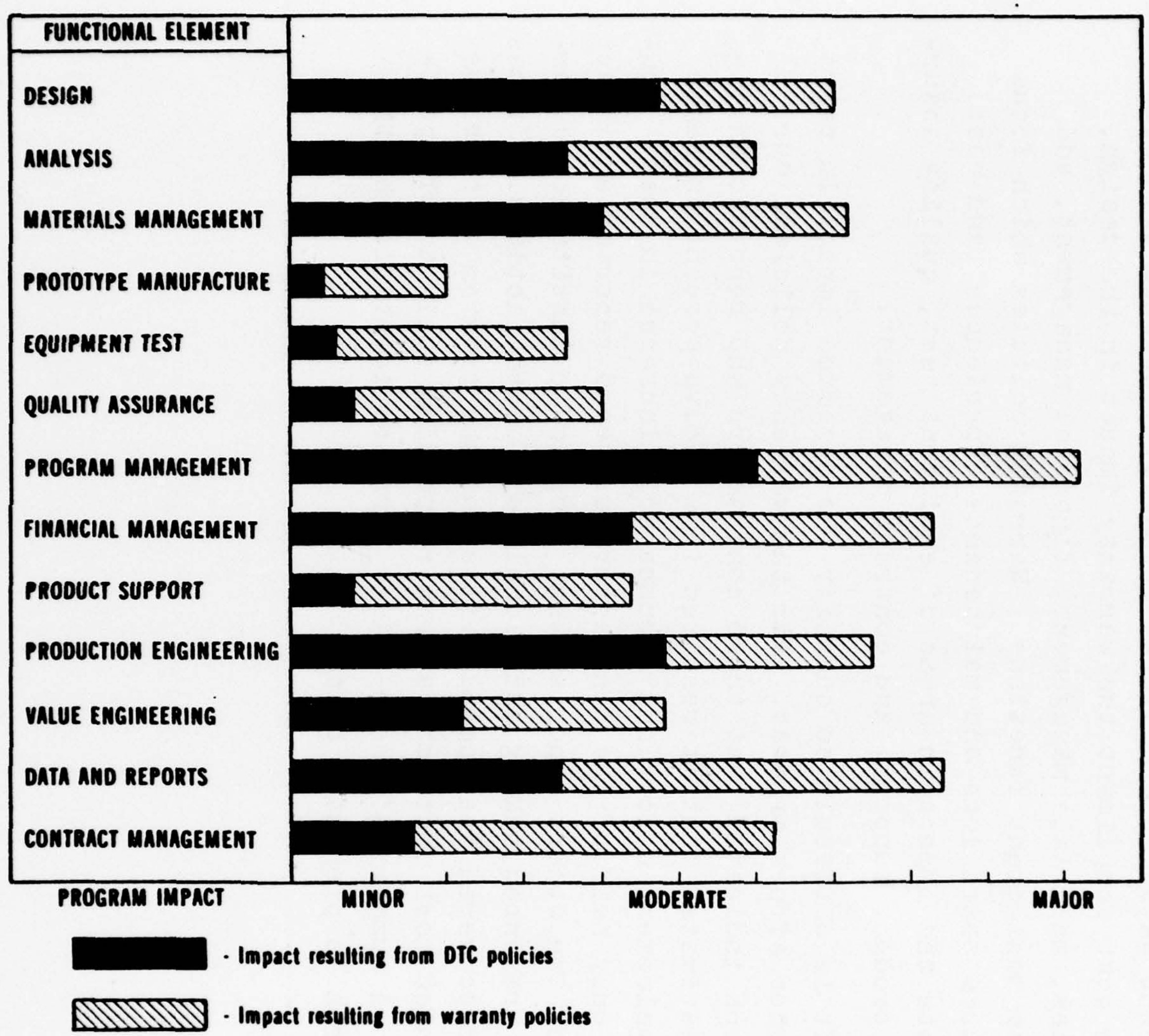

Figure 3. SUMMARY OF DEVELOPMENT PROGRAM IMPACT

IV
CONTRACTOR RESPONSE AND CONTRACTOR SUCCESS

It was not possible to draw conclusive cause and effect relationships between any specific development program characteristic and contractor success in winning the production contract. However, the consistent behavior of the winning contractors is interesting. Sixty-five percent of the successful contractors had formalized the DTC requirements with policies and procedures of their own. While there seemed to be no recurring pattern to the type of organizational structure, in every case except one, production or producibility engineering occupied a major place in the development program organization. Cost management also was a strong suit for the winning contractors. Another common characteristic was that the successful contractors developed a detailed cost estimating, tracking, and reporting system *independent* of contractual reporting requirements. In terms of program element impact, the tabulation of the successful contractors was also noteworthy. There was a three-to-one difference in effort reported between successful and unsuccessful contractors in almost every category examined. It is not clear whether other program characteristics such as technical performance may have been more important determinants of success than contractor response, but it is believed that the contractors who strongly embraced the intent of the policy initiatives were in a more confident posture when the production RFP arrived.

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V
BARRIERS TO CONTRACTOR RESPONSE

The contractor response observed for the recent acquisition initiatives was usually not optimum to pursue or achieve the policy objectives. It was commonly observed that the potential for a greater or more effective response was present, but institutional or program-unique barriers prevented this from occurring. The problem areas or policy barriers encountered, listed in order of their reported frequency, are shown in Table 4.

A full discussion of these and other program-peculiar problem areas is beyond the scope of this paper. However, some general observations related to contractor response are worth mentioning.

A recurring problem observed in many of the cases examined is that the expected policy outcome is often based upon the premise that the acquisition environment is favorable or can be easily modified to accommodate the new policies. Examples of this are (1) the expectation that there will be additional time and money available in the development programs to iterate equipment designs in order to meet pre-set design cost goals; (2) the expectation that the development test programs will provide realistic indications of expected operational reliability and maintainability; and (3) the expectation that new policies can be readily converted to contractual requirements and will instantly implement fundamental changes in contractor behavior. These expectations were never fully realized in the programs analyzed.

Table 4. POLICY BARRIERS AND PROBLEM AREAS

BARRIER OR PROBLEM	PERCENT OF CONTRACTORS REPORTING	POLICY IMPACT	
		DESIGN-TO-COST	RELIABILITY GUARANTEES
SCHEDULE RESTRICTIONS	85	MAJOR	MINOR
COST ESTIMATING UNCERTAINTIES	82	MAJOR	MODERATE
COST-PERFORMANCE TRADEOFFS	80	MAJOR	MINOR
ECONOMIC PRICE UNCERTAINTIES	72	MAJOR	MINOR
SUBCONTRACTOR/VENDOR MANAGEMENT	68	MAJOR	MAJOR
SPECIFICATION FLEXIBILITY	60	MAJOR	MAJOR
DEVELOPMENT FUNDING	60	MAJOR	MINOR
POLICY CREDIBILITY	55	MAJOR	MAJOR
POLICY REQUIREMENTS UNCERTAINTY	42	MINOR	MAJOR
CONFLICTS BETWEEN POLICIES	40	MAJOR	MAJOR
RELIABILITY PREDICTION	35	MINOR	MAJOR

Another problem area we found was that related policy concepts are not usually compatible when output priorities conflict. A policy calling for fixed-price guarantees of reliability, maintainability, or support cost will not be easily integrated into a DTC program whose firm unit production cost targets have already been set without R&M or life-cycle cost considerations.

Finally, the policies we've studied are designed to fundamentally change the way systems and subsystems are developed and acquired. In order for these changes to occur, the need for change must be clearly recognized and the benefits for change must be clearly visible--these are ingredients of policy credibility. If the contractor perceives a lack of credibility, policy response will be reflective and fundamental changes will not be implemented. In this case, credibility (or the lack of credibility) becomes a barrier to implementing change.

VI
FUTURE DEVELOPMENT PROGRAM PLANNING

Based upon our observation of recent policy initiatives and the subsequent contractor experiences and response, there are several lessons learned that could aid contractors in future development program planning.

The first is that successful contractors took the initiative, interpreted the intent of the policies, and translated policy intent into operating practice in advance and independent of Government contract requirements. This procedure was risky and increased financial exposure during the critical early development period. Successful contractor behavior during the development program was not unlike that of companies who were developing products for the commercial sector. However, institutional arrangements effectively blocked a full commercial response.

The second lesson learned is that these new policies can be implemented much more easily if major barriers to their execution are recognized and accounted for. The following conditions should be present for new acquisition policy success:

1) The Government program office must firmly believe in and endorse the policy.
2) The policy must be appropriate to the development program under consideration.
3) Sufficient time should remain in the development program to accomplish the goals of the policy.
4) Flexibility should be incorporated as part of the program to reverse previous decisions if the new policy requires a changed product design or development program.

5) Contractual requirements for policy application must be analyzed and agreed-to at an early stage.

6) Areas of policy interference with present program policy and planning should be analyzed and resolved.

7) Additional funds, if required, should be available to execute the development program in accordance with new policy guidelines.

The major lesson learned is that policies aimed at reducing total product life-cycle costs will probably require more time and effort during development than otherwise would have been expended. Basic development engineering disciplines such as design, analysis, test, and evaluation, together with program management, will be affected. Indirect functions such as financial management, materials management, and contract management may also require more effort to properly analyze and implement the policies. Ways should be explored to efficiently expend these valuable front-end dollars which can have great leverage on the cost and outcome of the total program.

VII
CONCLUSIONS

Contractor response to recent acquisition policy initiatives was examined. It was found that new policy application to the initial programs often was only partially effective because of improper timing and delays in policy acceptance. Nevertheless, significant contractor response was found in areas of policies and procedures, organizational structure, cost management, and development program planning. It was found that beneficial contractor response usually required more development time and effort. The potential for a greater and more effective response was identified if institutional and acquisition environment barriers could be attenuated or eliminated.

Changes in contractor behavior leading to improvements in system and subsystem cost, reliability, and maintainability are difficult to implement exclusively through new policy initiatives. Positive contractor response will depend upon many factors ranging from the perceived credibility of the Government to the successful accommodation of policy barriers contained in the present acquisition process.

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